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ART. XVII.—*Mineral Resources of Southern India.*—No. 1.
Copper Districts of Ceded Districts, South Mahratta Country,
and Nellore. By LIEUT. NEWBOLD, F.R.S., &c.

(Read February 19, 1842.)

THERE are some excavations, said to have been made under the direction of Hyder, on the lower ridge of the copper mountain range in the Ceded Districts, five or six miles westerly from the cantonment of Bellary, in about lat. $15^{\circ} 5' \text{ N.}$, and long. $76^{\circ} 59' \text{ E.}$; they were given up, according to native information, in consequence of the little profit yielded. The ore,—the green carbonate of copper,—I found in thin layers, filling up seams, and interlaminated with a slate-clay and slate, resembling the killas of Cornwall, which is associated with hornblende and chloritic schists, alternating with gneiss in conformable strata. The former contain thin veins of crystalline marble, and, with the gneiss, have been penetrated by large basaltic dykes. Bosses of granite are seen in the plain at the base. The highest peaks of the range are capped with a ferruginous cellular rock resembling laterite, and resting horizontally on the highly-inclined strata of the crystalline schists; it exhibits efflorescences of impure muriate of soda and sulphate of alumina; the latter resulting, probably, from the decomposition of iron pyrites which are occasionally found in this rock. Depositions of kunker are seen at considerable elevations, on the sides of the range, and often covering, in beds of variable thickness, the rocks in the plain. The excavations made in search of the ore are not of great magnitude, and must have been speedily given up. I was unable to detect any distinct lode. I have observed indications of a similar ore in the plumbiferous district of Jungumrazpilly, in the Cud-dapah Collectorate, Ceded Districts.

South Mahratta Country.—The third locality in which copper ore occurs is an alluvial one, viz., the sands of the Doni, a rivulet flowing from the Kupputgode hills in the collectorate of Darwar, whose geological structure resembles that of the copper mountain range. Besides copper ore (the carbonate), the sands contained a considerable portion of gold-dust, magnetic iron sand, traces of silver, platinum, and menaccanite. Beds of chert, used by the Moham-medans for gun-flints, occur in this range; and in 1839, I discovered a large vein of black manganese (associated with magnetic iron ore), which had been mistaken for coal. The whole of this

wild hilly district deserves a more minute examination by a competent geologist, attended by an intelligent practical European miner, since I have little doubt of its being the situs of the metals and ores found in the brook.

Nellore.—But the most promising copper country in South India is unquestionably that of Nellore, lying along the eastern base of the East Ghauts, and stretching northerly from the Pennaur to the Kistnah, between the 14th and 16th degrees of N. lat., and the 79th and 80th E. long. The principal mines are situate about thirty-six miles W. from the coast of Coromandel, and thirty-six N.N.W. from Nellore.

I shall now proceed to give a description of these mines as I found them in January, 1840.

Passing easterly from Cuddapah towards the sea, the spur of the Eastern Ghauts, on which the Jungamanipenta lead mines occur, is crossed to the valley of Budwail; thence, over the main range, by the Dorenál pass, the traveller descends into the plain of Nellore, and passes in a N.E. direction along the foot of the Ghauts, whose mural summits here attain, as I ascertained by trigonometrical observations, an average height of 702 feet above the elevated land at their base.

Physical Aspect of the Copper District.—The country presents an undulating plain, extending from the foot of the Ghauts easterly to the Bay of Bengal, and studded with a few detached round-backed hills of gneiss, mica, and hornblende schists, rarely attaining a height of 250 feet above the level of the adjacent country. Its surface is furrowed by the channels of rills and streamlets which, during the monsoons, descend the mountain sides, and, collecting in the bed of the Pennaur to the southward, flow on easterly to the sea. The course of these streamlets indicates the general inclination of the plain, whose approximate heights, near the base of the Ghauts, at Kunchgarlaconda, I found, by means of the boiling-point of water, to be 835 feet above the sea's level.

It is covered with a dark red alluvial clayey soil, mixed with sand, partly washed down from the hills, and partly the detritus of the subjacent rocks. A few patches of a dark-brown vegetable mould, of a rich nature, are sparingly interspersed. The surface is in many places strewn with both angular and rolled fragments of quartz, flinty slate, nodules of kunker, hornstone, &c. The subsoil varies from a few inches to ten or twelve feet in depth; and, from its impervious and often suliferous nature, is sterile and neglected. Large tracts between Yerrapilly and Curruimaldinny are almost

without a blade of grass. Nothing but the hardiest mimosas seem to have the power of life in those spots, where efflorescences of native subcarbonate of soda are seen, like thin sheets of snow, spread over the surface. Beds of kunker (nodular and compact carbonate of lime, containing a small proportion of magnesia, oxide of iron, silicious and aluminous matter) often form the subsoil, particularly in the vicinity of basaltic dykes. They appear to have been deposited by springs, rising up through fissures in the primitive rocks, and connected, probably, with the phenomena attending the intrusion of the dykes: to the agency of which may be attributed, in some measure, the great tendency to crystalline and metallic development observable in this district.

The temperature of the springs in this plain, in January, averaged $80^{\circ} 1^{\circ}$ Fahrenheit—a temperature slightly exceeding, perhaps, the mean temperature of the air.

The vegetation is of a stunted character, owing to the sterility of the soil: irregular patches of low jungle, consisting chiefly of mimosæ, euphorbia, cassia auriculata, carissa spinarum, asclepias gigantea, Ixora parviflora, and the myrtle-like bushes of the bunder, are interspersed over tracts bristling with prickly spear grass. As the sea is neared, the monotonous aspect of the vegetation is relieved by the appearance of the graceful fan-palm, the tall cocoa-nut, and the odoriferous date-palm.

The vegetation of the valleys and lower parts of the Ghauts is of a more arboreous character than that of the plain, producing timber trees of considerable size, and wood adapted for the purposes of smelting. Among the trees I observed the *Dalbergia latifolia*, *Pterocarpus santalinus*, *Erythrina Indica*, *Mimosa Xylocarpus*, *Melia Azadirachta*, *Ficus Indica*, *Mangifera* and *Tamarindus Indica*: Teak, *Tectona grandis*, is also said to occur: the *F. Annona tripetala* is found in the wild state: the *Zizyphus jujuba* is common.

Geognosy.—The rocks in the plain comprise gneiss, mica, and hornblende schists, highly garnetiferous, alternating in conformable strata, and, in general, dipping westerly, at an angle of from 20° to 70° ; much disturbance in the stratification was remarked, especially near the mining districts. The gneiss embeds drusy crystals of actinolite, adularia, kyanite, schorl, cleavelandite, and asbestiform tremolite. The mica schist is generally of a silvery green hue, becoming reddish in disintegration, often highly splendid, with waving and contorted laminæ, between which, at the eastern base of the Udigherry Mountains, I observed a mineral of a carmine red colour, in shining opaque plates, sparingly interspersed.

Before the blow-pipe, *per se*, it curls up and fuses readily with intumescence and phosphorescence, into a white enamel: on charcoal, with phosphate of soda, it melts into a topaz-coloured glass, which, on cooling, becomes colourless: with borax, into a glass of a faint green tint, which also loses its colour in cooling. The mineral is softer than felspar,—streak, reddish white. The hornblende schist is of a highly crystalline character and passes into amphibolite; its colour dark green, approaching black; magnesite is said to be occasionally found in it. All these rocks are traversed by large veins of quartz, embedding rock crystal, both white and rose-coloured, actinolite, schorl, and garnets. Magnetic iron ore, sometimes associated with manganese, abounds in these veins, and in the embedding rocks. Conformable beds of a granular garnet rock occur near Gurumanipenta in the hornblende and mica schist, which, in the hand specimen, is liable to be mistaken for granular corundum, and might be advantageously substituted for emery in polishing stones, gems, &c. It often occurs in a nodular and crystalline form, assimilating dodecahedrons, or prisms, with three-sided summits; is associated with asbestiform tremolite, and adularia, and passes into quartzite. The most numerous and finest crystals of garnet occur in the gneiss: many assimilate essonite: colophonite, common in similar hypogenic rocks on the opposite coast, was not seen.

Granite is rarely visible, except in veins traversing the rocks just described: but basaltic dykes are very numerous, embedding acicular crystals of augite, and cubic iron pyrites, and passing into melaphyre. As a general rule, in the vicinity of these dykes crystalline development is observed to be at its maximum, more especially that of garnets. Near the line of contact, the micaceous portions of the rocks are hardened and consolidated, and the felspar rendered more compact, often approaching the character of petrosilex: the quartz remains unaltered. Eurite occurs in beds subordinate to the gneiss. The basis of the ghauts consist of the rocks just described, capped by sandstone, passing into petrosilex or hornstone, forming mural escarpments, facing towards the S. E., with tabular summits.

Mines of Kunchgarlaconda.—I shall now proceed to notice the excavations in detail, commencing with the most westerly, viz., those of Kunchgarlaconda. A little to the E. of Samulrayacotta, a low spur of the ghauts, running N. to W., is crossed, consisting of a bed of quartz in a leptinitic gneiss, alternating with mica schist. From this spur the mines take their name: they are

marked by heaps of rubbish, thrown out of a series of half-choked-up excavations, that run along and near the ridge. The ore here is the green carbonate: I picked up several fragments of malachite, from a lode about an inch thick in the quartz rock. The latter is, in some places, perfectly honey-combed, with small cavities, occasioned by the disintegration of the ferruginous mineral which formerly filled them, and which is still visible in the form of an orange-brown coloured dust, which blackens and becomes magnetic before the blow-pipe. Seams of a blackish iron ore, combined with manganese, and resembling graphite in external appearance, about one-quarter of an inch thick, were observed. The dip of the strata in this locality is 48° W. 10° N. A basaltic dyke, running nearly E. and W., is seen in the plain at the eastern base of the ridge, underlying a bed of kunker, ten feet thick. The mines were deserted. The locality offers great advantages, from its height and situation, for draining any shaft of moderate depth that might hereafter be sunk.

Salghirry Mine.—The old mine lies about half a mile S.W. from Gurumanipenta in the plain, but was nearly filled with water. A few paces to the E. of it a new shaft had been recently sunk by that spirited and intelligent British merchant, J. Ouchterlony, Esq., of Madras, to the depth of about ten feet, through a superstratum, a few feet deep, of dark-red alluvial soil, mixed with nodular kunker, ferruginous pebbles and fragments of the subjacent rock, which is gneiss abounding with mica. The lode runs through it, near a vein of quartz in a S.E. direction, dipping at an angle of 70° towards the N.E., about three or four inches thick. It presents a few patches of green carbonate of copper and reddish spots and cavities, technically termed "gossings" by the Cornish miner. A spring of water, oozing through the lode, had been met with about five feet from the surface, which, left to itself, fills the shaft with water to the depth of ten feet, in the space of twelve hours. The pump had unfortunately been broken, and the miners were constrained to keep the shaft clear with the buckets and windlass, which were used to carry up the excavated portions of rock.

Among the refuse of the old excavation, I found a fragment of gray sectile, malleable, sulphuret of copper, rich in metal. The surface of the recent fracture was rather flat and splintery, lustre metallic, and of a bluish-gray colour; externally, rusty brown. The fragment was coated partially with green carbonate of copper, and from its shape and dimensions was evidently a section of a continuous vein of rich ore, about half an inch thick.

The sands of the rivulets in this vicinity abound in fragments of garnet, actinolite, and schorl, embedded in quartz with large nests of a silvery foliated mica, hæmatitic and magnetic iron ore, magnetic iron sand, and liver-coloured iron pyrites. Gold dust is said, by the natives, to be found, though in minute quantities.

Mines of Nila-gunni.—There are three excavations about one-quarter of a mile southerly from the village of Gurumanipenta, beyond the two tanks in the plain. The nearest is the most considerable, but was filled with water, hence termed *Nil* or *Nila gunni*: its superficies is about fifty paces long, by four or five broad, and terminates in a circular pool about ten paces in diameter. Its longest diameter runs nearly N. and S. The superstratum is a bed of kunker, cementing fragments of the surrounding rocks, ferruginous nodules, &c., overlying the mica, and hornblende schist embedding the ore. Among the rubbish are many fragments of both mountain green and malachite, disseminated and in thin layers in quartz veins. Where the quartz is transparent the thin seams of ore intersecting it impart a green colour to the quartz itself, like coloured foils to the colourless crystal beneath which they are set. A few fragments of the rich sulphuret described already, are met with, associated with the carbonate. The two other excavations in this vicinity are of inferior depth, and nearly filled up. They were all deserted, and no signs of recent working apparent. The sides of the fragments of ore in the hornblende schist in contact with the matrix are generally coated with oxide or sulphuret of iron, and have a flat compressed appearance.

Bungheral Metta Mines—are situated on rising ground, about two miles N.W. from the village of the same name, lying between the junction of the Pillap-eyrú and Upet-eyrú streams.⁴⁰ One of the excavations is of great size, occupying an area of several hundred square feet, and having a depth of about forty-five feet. Mr. Kerr, who saw this mine several years ago, states that on clearing away the matrix rock, and rubbish that had accumulated in these immense tanks, the mouths of galleries extending into the rocks were discovered: but at the time of my visit they were no longer visible, in consequence of the accumulation of water. The ore is the green carbonate, occurring in a ferruginous gangue with the sulphuret, and in regular thin layers between the laminæ of the hornblende schist, also in thin vertical seams, often crossing the direction of the laminæ at right angles. The principal lode is about two inches thick, and can be traced to the water. The lamented James Prinsep, whose premature decease India must ever deplore, thought the

phenomenon of the ore alternating with the hornblende rock highly interesting in a geological point of view, as affording exactly the appearance of gradual deposition from a liquid, at this earliest period of geological formations. Mr. Prinsep formed this opinion from the hand specimens sent to him at Calcutta: had he seen the rock *in situ*, with seams of ore running through it in fissures, often at right angles with the other layers and lines of stratification, he would not have pronounced the ore to be coeval with the hypogenic rock embedding it, nor referred its occurrence to mechanical deposition from a liquid. Joints are observable in the hornblende schist, running nearly at right angles with the planes of stratification: it is also intersected by almost vertical fissures, indicative probably of subterranean disturbance; for, even at the present day, shocks of earthquakes are not unfrequent, and subterranean sounds are said to have been heard in the vicinity. The rocks are covered here with the usual superstratum of kunker, which has often penetrated and filled up the fissures and seams in the rocks. Schorl occurs in beautiful striated prisms with quartz and mica.

Near the Upet-eyrú stream, a shaft, having a gentle inclination, had been recently sunk into the gneiss by Mr. Ouchterlony's people, about six feet wide, five and a half feet high, and about sixteen paces long: it terminated at a bed of a white earthy rock, resembling kaolin, or porcelain clay, in a highly indurated state, into which I was unable to trace the continuance of the lode.

Cumbaldinny Mines.—On the opposite bank of the Upet-eyrú, at the distance of about two miles, lie the excavations of Cumbaldinny, only one of which I had time to examine, as night was fast closing in: the ore, the carbonate, occurred in thin seams and layers in the hornblende rock, from a few lines to two inches thick, and from two to eight feet apart.

Yerrapilly Mines—are about five miles N.E. from Gurumani-penta: one lies about a mile northerly from the hamlet of Yerrapilly, and the other about the same distance to the S.E. The former is an excavation about ten feet deep, having two feet of water at the bottom. It was probably opened by Dr. Heyne, as there were still visible two layers of ore, (both the sulphuret and carbonate,) stated by him to occur here. The rock cut into is gneiss and mica schist, overlaid by a bed of kunker, and embedding schorl, hornblende, actinolite, asbestiform tremolite, and kyanite. The other mine is a superficial excavation in hornblende schist: at a little distance is a bed of mica schist, containing a vein of tremolite, associated with adularia in pearly rhomboidal crystals. I could not

detect the ore here *in situ*, though water-worn fragments were scattered on the surface: garnets abound.

Mines of Adimutipuram, &c.—At Adimutipuram, a village a little to the S.E. of Yerrapilly, between it and Currumaldinnypaud, traces of copper ore, principally the carbonate, are found in the rubbish thrown out of two wells, one dug in the gneiss, in which the mica is replaced by innumerable garnets, and the other in a bed of hornblende rock, also highly garnetiferous. Stauroilite, or prismatic garnet, cleavelandite, and tremolite also occur. About half a mile southerly from Currumaldinnypaud, on the bank of a small rivulet, rolled fragments of carbonate of copper are found in a heap of alluvial matter. This is the most easterly spot, according to the information of Gopaul, head Wudra of Gurumanipenta, where traces of the ore have been found, and this evidently not *in situ*. According to the same authority, excavations occur in the inauum lands of Pota Bram Reddy, of Buchi Neddipuram, at Gutti Gondala, also at Agni Gondala, and Mudiyeemmal, one and a half gow from Innaconda, and also at Gogulapilly, five gows' distance from the same place. The last traces of copper to the eastward which I observed, were in the micaceous and quartz rocks of the Jungum, or point of confluence of the Pennaur and the Bogh and Beyrap-cyru streams, W. by N. from Nellore. Between Yerrapilly and Currumaldinnyp, and particularly near Adipuram, the surface of the soil is singularly mottled with large glittering crimson patches, which consisted entirely of comminuted garnet.

Analysis of the Ores.—The copper ores of Nellore have been analysed in England by Dr. Thomson, and more lately in India by the late Mr. J. Prinsep¹, who was unable to detect the existence of silver in them, or other metal except iron. He found the sulphuret to be the richest: in his specimens it was combined with the carbonate, yielded 69 per cent. of pure metal, and had a specific gravity of 3.77, intermediate between that of the pure carbonate, 3.2, and the sulphuret, 4.5. Its chemical composition is thus expressed:—

Hydrated carb. of copper	31.7
Sulphuret do	63.0
Oxide of iron, silice, &c.	5.3
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	100.

Its richness, he states, will more than compensate for the increase of trouble and expense in the reduction of the ore by successive roastings; and practical miners assert, that the glance, or gray sul-

¹ *Asiatic Journal of Bengal*, vol. iv., p. 674.

phuret, is a much steadier and more plentiful ore than the carbonate. Dr. Heyne, it would appear, mistook this sulphuret for Dr. Thomson's anhydrous carbonate, new to mineralogy, said to have been obtained from this locality, and from which all the specimens examined by Mr. Prinsep differed materially.

The green carbonate, associated with quartz, yielded 30·2 per cent. of metal; its chemical constituents are as follow :—

Hydrated carb. of copper	52·4
Sulphuret of iron	2·1
Oxide of iron, silice, &c.	43·5
Loss, or excess	2 0
	<hr/>
	100·

The Bungheral Metta ore, consisting of carbonate of copper, running through a ferruginous matrix, in veins mingled with sulphuret of iron, and probably copper with the oxide, giving the whole a dark arenaceous texture, yielded 39·5 per cent. on the first analysis; but in a second experiment the copper actually recovered so much exceeded that quantity, that it was evident the ore frequently contained the sulphuret, or was of very variable quality; its chemical composition is as follows :—

Hydrated carb. of copper	68·5
Sulphuret of iron	12·4
Oxide of iron, silice, &c.	25·1
Loss, or excess	6·0
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	112·

The excess, Mr. Prinsep thinks, is owing to the irregularity of the rocky admixture in different specimens, whereof one yielded 44, and another only 13·9 of insoluble matter on digestion in acid.

History.—The origin of the most ancient of these extensive excavations is lost in obscure tradition; but the most respectable native authorities refer them to the ancient kings of the Bijanugger dynasty, within the limits of whose empire they were situated. They did not escape the notice of the Mogul conquerors after the downfall of the Hindu empire at the battle of Talicota, in 1564 A.D.; nor of the emissaries of Hyder and Tippoo; but of the manner of working them, process of smelting, and amount of produce, we have, as yet, no farther evidence than the magnitude of the excavations themselves, and the extensive mounds of ancient ferruginous slag and scoria, indicating the situation of the old smelting furnaces. Most of these mounds are covered with vegetation. A fragment of the slag analysed by Mr. Prinsep, yielded but faint traces of copper, showing that the native processes of extraction, however rude, were

effectual in completely separating the metal. Mounds of slag of iron furnaces, formerly uncommonly numerous in these districts, are scattered over the country, and must not be confounded with those of the copper furnaces. Iron is still smelted by the natives, though by no means so extensively as in ages past.

To Dr. Heyne, I believe, the merit is due of having first brought the copper mines of Nellore, about forty-seven years ago, under the consideration of the British Government, in an able report published in his tracts on India. About seven or eight years ago, Mr. Kerr entered into a speculation for working them, which failed, partly through mismanagement, but chiefly from want of capital and support. Late in 1839 they were again taken in hand by J. Ouchterlony, Esq., of Madras, who has judiciously established a practical Cornish miner on the spot.

Concluding Remarks.—The most promising localities are those of Nilagunni and Salighirry, particularly the former, where the richest ore, the sulphuret, exists in the greatest abundance: both, however, are subject to serious objection on account of the prevalence of springs, the draining of which would greatly enhance the expense of working. Those of Kunchgarlaconda are free from this objection, and the "gossings" there are favourable. The excavations at Bungheral Metta are first in magnitude, and being on a high bank, the base of which is washed by a river, can be drained with greater facility. The quality of the ore is good, and the principal lode distinct and clear: an immensity of labour has been there thrown away by the ancient miners; a tank has literally been cut in the solid rock, and, for the most part, through a dead country, where a shaft, six feet high, and as many wide, would have been amply sufficient. Nothing permanent, or certain, can be expected from the deposits at Adimutipuram and Yerrapilly, which are principally alluvial. The *situs* of the ore, however, cannot be far distant, judging from the little-worn aspect of the nodules. There is said to be a cavern at Kisten-rayna-conda, but whether artificial or natural has not been ascertained: it should be examined as well as the range in the vicinity, where, I am informed by the natives, traces of copper have been discovered.

As a general rule, though there are many exceptions, it may be observed, that the metalliferous veins run in a direction from S.E. to E., and are more numerous near the junction lines of the alternating crystalline schists, or in the proximity of basaltic dykes: their dip is usually at a great angle.

The expenses of smelting cannot be very great, as charcoal is

sold at the low rate of three maunds for one anna: it is made principally from the wood of the Dewadári, the *Dalbergia latifolia*, the *Cassia auriculata*, and the *Asclepias gigantea*. The charcoal obtained from the last is used by natives with that of the common *Euphorbia* of the plains, in the composition of gunpowder: its green leaves and the dried wood of the *Cassia auriculata* are used in the conversion of iron into steel, by subjecting them for two or three hours to a red heat in a closely luted crucible, in contact with bar iron cut into small pieces. Timber for machinery is everywhere procurable, and sells at the cheapest rate: iron is also abundant. The ore yields seventy per cent. of metal, and is sold, after being stamped and washed, to the smelters, at from five to six rupees the candy of thirty maunds. The principal depôts are Yercul, Injimoor near Dotalúr, and Wootcoor, where the celebrated wootz steel is manufactured. The cocoa-nut trees near the coast afford an ample supply of coir for ropes. The population of the district is of an industrious character: that of Gurumany, or Gari-penta, which place may be considered as the capital of the mining area, contains chiefly natives of the *Upér* caste, whose business it is to dig wells and tanks. Ramapatam on the sea-coast, only thirty-eight miles distant, offers an eligible port for the embarkation of the ore or metal for Madras, (which lies about 110 miles S. S.E.), and other ports. Dr. Heyne hints at the practicability of navigation of the river which runs by Gurumanipenta, but from what I saw of this stream, I should recommend a more careful survey previous to its services being taken into any calculation. The course is tortuous; the supply of water in the hot season scant and variable, and used by natives for the irrigation of their fields; the bed rocky and shoaly: in the monsoon it might possibly be rendered available. I shall now conclude with briefly remarking on the absurdity of associating the pursuit of mining, as has been even done with regard to our manufactures, with avarice, immorality, drunkenness, and every other vice that degrades humanity, since we know, from the observations of Humboldt, and other enlightened travellers, that the exercise of this art, which is intimately connected with the highest branches of physical science, has produced in desert and sterile wastes, a flourishing and industrious population, and conduced materially to wealth and civilization. On the other hand it must be stated that, under a bad government and improper management, it has become the last stake of desperate speculation; and, like other commercial schemes, has proved the ruin of thousands.